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Traditionally, DoD has approached instrumentation as an afterthought. This was not because instrumentation was not an important part of the acquisition process, Mostly, it was because there was adequate funding for the program and the instrumentation budget was buried in the noise. For years weapons platforms were developed with whatever instrumentation system was desired by the contractor. After EMD, when the test vehicles were turned over to the DoD, a lot of infrastructure was required to maintain sparing levels, maintain support equipment, and keep personnel trained. With today's diminishing defense budget, everything gets scrutinized, including instrumentation.
Data requirements are increasing to feed information hungry simulations. At the same time. Local area network (LAN) speeds are reaching 10 - 100 time current instrumentation busses. Through sheer volume in the computer industry, PC's and peripherals are available at unheard of prices. A good way to keep instrumentation affordable was to leverage off the commercial sector.
NexGenBus has researched available commercial busses and found several possible candidates. These candidates were investigated and revealed Fibre Channel as the most promising. Currently, Fibre Channel is being tested and analyzed in more detail to decide if it will be useful as an instrumentation bus.

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TECOM Test Technology Symposium '99

"Enabling Technologies for Affordable Testing"

Next Generation Instrumentation Bus (NexGenBus)

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Abstract

Traditionally, DoD has approached instrumentation as an afterthought. This was not because instrumentation was not important part of the acquisition process. Mostly it was because there was adequate funding for the program and the instrumentation budget was buried in the noise. For years weapons platforms were developed with whatever instrumentation system was desired by the contractor. After EMD when the test vehicles were turned over to the DoD, a lot of infrastructure was required to maintain sparing levels, maintain support equipment, and keep personnel trained. With today's diminishing defense budget, everything gets scrutinized, including instrumentation.

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1 Background

Test instrumentation was never high on the priority list when a new development was started. As EMD approached, thoughts turned to measurement lists, measurement rates, and data collection devices. The instrumentation engineer designed a system to collect, store, and transmit the data using components that would fit in the available space. These systems were centralized data systems. Transducers throughout the aircraft were individually wired directly to the data system. This resulted in large wiring bundles being routed throughout the aircraft. Adding additional parameters after the fact was nearly as large an installation effort as the original design.

As instrumentation designs matured, the distributed system was introduced. These systems had proprietary busses connecting the system controller to multiple units throughout the aircraft. The transducers were wired to these local data units reducing the amount wiring required throughout the aircraft. The distributed data system allowed new parameters to be added to the system more efficiently. However, distributed systems increased the complexity of the system and required a higher level of understanding. The unique interfaces between the controller and remote units did not easily allow multivendor solutions.

When the development test program is complete, the weapons platforms are signed over to the government. The ranges have to take over the operation and long term support of each of these systems. Maintaining trained personnel and appropriate equipment sparing levels for each system type is not a trivial task. System support is aggravated as the equipment gets older and breaks more often. Vendors will improve their designs that many times are not backwards compatible. The cost and time associated with maintaining these older systems is multiplied by the number of different system types requiring support.

As some of the older data systems had to be replaced due to obsolescence, the high life cycle cost was realized. This fed the understanding that a standard system was required. The DoD has currently standardized on the CAIS Bus as a common instrumentation interface. With the CAIS Bus, multivendor solutions have been achieved. Multiple platforms are using CAIS based systems that will allow personnel, test equipment, and flight units to support each other in times of need.

2 The Need

With Defense budgets shrinking, there is an increased need to perform both effectively and efficiently. All aspects of development programs are being scrutinized, including testing and instrumentation. To reduce overall costs, testing is being reduced in favor of more simulation. Simulation of complex systems require huge amounts of data to validate the models. The new paradigm is to support simulation by gathering more data on fewer flights while reducing costs. The increased fusion of data from numerous sources (i.e. analog measurements, digital buses, digital radar data, and digitized video) to support testing and simulation will overwhelm current bus rates of 10 Mbps.

To achieve the required throughput, a new bus will be required. The cost in time and money to develop a robust serial interface document, prototype it, test it, and put it in production is staggering. However, for a couple of hundred dollars, many standards are available from IEEE, ANSI, and SAE. These standards were developed using some of the best minds industry has to offer. By using a commercial interface standard, the purchasing power of industries like the consumer PC market could be leveraged as well.

3 The NexGenBus Approach

3.1 Research

Before evaluating the commercial busses, the system features of a composite future data acquisition system were identified. The composite system included elements of data systems existing today along with future elements envisioned by the NexGenBus team. This enabled the NexGenBus team to understand the type of data acquisition system a future instrumentation bus must support. One of the major features of a such a system is the ability to bridge to data acquisition units on other busses allowing existing instrumentation inventories to be used. Other features included open system architecture, simultaneous sampling, various data inputs and outputs, smart transducer support, environmental constraints, and network topologies.

The composite system definition was used as a framework to define the NexGenBus requirements. This method enabled the team to track the NexGenBus requirements to a specific data acquisition element. For each data acquisition element the required bus characteristic was determined. The bus requirements list included quantitative instrumentation measurements such as vibration and acoustic sampling requirements, digital data (serial and parallel), video (weapons release) and audio requirements. As insights and information were gained on the bus characteristics, the requirements list was updated.

A comprehensive search was implemented for non-proprietary communications busses. This search entailed generic open searches on the web using several of the more prominent search engines. This was closely followed by thorough searches of standards organizations such as IEEE, ANSI, and SAE. Trade journals and technical magazines provided a lot of timely information on trends and busses being used in the industry. The search turned up more than thirty-three busses.

3.2 Bus Selection

Some of the larger instrumentation systems in use today have data rates exceeding 50 Mbps through the use of multiple busses and multiplexers. The correlation of time sensitive data across these multiple busses can be tricky at best. To ease this burden, there is a need to combine numerous sources (video/data/voice) onto a very fast bus. With this in mind, the minimum requirement for bus speed was considered to be an order of magnitude greater than the current 10 Mbps standard. Eight serial busses with rates greater than 100 Mbps were identified. These eight busses were selected for review and grading. The purpose of this stage was to quickly eliminate those busses that could not meet minimum requirements. The standards for each of the eight busses were considered as documented. Deviations from the standard in current practice were not considered. Examples of the criteria the busses were graded on included:

- Physical (length of cable, specified cable types, installation environment)
- Rates (burst rates, operating speeds)
- Error Control (BER, fault tolerance)
- Field manufacturability of cables/connectors
- Cable diameter/bend radius

The final grading on the eight busses showed three clear winners, Fibre Channel, FireWire and Gigabit Ethernet

These three busses were selected for further study. For this final selection, supportability issues were used along with the technical parameters. A questionnaire to industry was generated to solicit responses for requirements of a networked instrumentation bus. The down-select criteria for this third cut considered three main areas, Standards, Performance and Commercial.

Standards
- activity
- working groups
- maturity

Performance
- Protocol
- Synchronicity
- Class of Service (CoS)
- Guaranteed Delivery
- Physical
- Topology
- Interconnect Spectrum
- Data Rate

Commercial Acceptance
- News Articles
- Products/Availability

Each bus was rated high, medium, or low on the 13 items shown above. The ratings were converted to numerical scores with the average scores (out of 10) shown in the table below. Fibre Channel again was the hands down winner. This evaluation supports what is being seen in other DoD activities. Of the three busses, ***Fibre Channel is the only one being used in a military flight environment.***

Bus	Avg Score
Fibre Channel	**8.85**
Gigabit Ethernet	5.00
Firewire	4.46

3.3 Testing

Fibre Channel was the clear winner in each phase of the down select and was selected for lab testing. The goal of the test program is to identify weaknesses in areas critical to instrumentation. Whenever possible, ways to work within the standard to avoid these weaknesses will be noted. The test program will be accomplished in a number of ways. The most obvious way is to actually test a device in the lab. However, because COTS end-items will be used, there won't be access to the same level of test points found on development units. Other methods that will be used include analysis, inspection, and adoption of test results performed elsewhere.

There are multiple protocols that can be run on top of Fibre Channel. Choosing the best one will be difficult. Part of the test program includes simulating a data acquisition network using various protocols on top of Fibre Channel in order to select the best one(s).

3.4 Instrumentation Profile

Assuming Fibre Channel is determined to be capable, an instrumentation profile will be generated. A profile is a document describing how to use a given standard for a particular application. In its simplest form, the profile would say, "See ANSI X3.230". However, more than likely there will be restrictions or clarifications noted when using Fibre Channel as an instrumentation bus.

4 Conclusion

The pace of technology development and the capability that exists in the commercial sector has provided the instrumentation community a tremendous opportunity. Fibre Channel is already proving successful in some avionics applications. If it proves useful as an instrumentation bus, it will increase the bus speed by two orders of magnitude over current systems. The NexGenBus project is effectively using COTS products to keep testing capable and affordable.

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Next Generation Instrumentation Bus

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Background

- Centralized data systems
  - Difficult to add new parameters
- Distributed data systems
  - Increased complexity
- Standardized interface
  - Multivendor systems possible
  - Common system knowledge

The Need

- Data
  - High fidelity simulation models
  - Multisource, time correlated test data
    - Digital video
    - Digitized voice
    - Avionics/Radar busses
    - Transducers
- Reduce cost

The NexGenBus Approach

- Research
  - Defined instrumentation system requirements
  - Derived bus requirements
  - Identified more than 33 possible busses

The NexGenBus Approach

- Bus Selection
  - 33 possible busses
    - 100 Mbps min (10 times greater than current sys)
  - 8 potential busses
    - Rate, BER, Copper/Fiber Optic, etc
  - 3 viable busses
    - Fibre Channel, Firewire, Gigabit Ethernet
    - Standard, performance, industry acceptance
  - Fibre Channel Selected for Testing

The NexGenBus Approach

Testing

- Identify weaknesses in areas critical to instrumentation
- Using commercial standard and COTS end-items
  - Lab Tests
  - Analysis
  - Simulation
  - Third party test reports

The NexGenBus Approach

- Instrumentation Profile
  - Instructions on how to use the standard for instrumentation.
  - Working with the Fibre Channel Avionics Environment Working group (FC-AE)

Conclusion

- Fibre Channel is being used in airborne avionics applications
- Instrumentation use looks promising
- NexGenBus is keeping testing costs low and capability high through the use of COTS